Space Weather Technical Forecast

Issued on Thursday, 25 January 2024 at 01:08 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrivals possible later 25 January into early 26 January, with G1/G2 storming likely. Moderate solar activity likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with numerous M-class flares from AR3559 and AR3561, peaking with a M2.6 at 24/0140 UTC. There are currently seven sunspots on the visible disc. AR3561 and AR3559 are the two largest, most complex and active regions, both showing significant magnetic complexity and contain delta regions, though both also displaying some minor decay in areal extent recently. AR3555 is situated close to AR3561, a delta spot is now evident in its southern trailing portion. These two spots are magnetically linked, adding to the overall flare risks. The remaining spot regions are small and simple at present.

There have been several CMEs emerge in the last 24 hours, most of which are expected to be missing Earth. Close monitoring and reanalysis of any CME continues when imagery allows.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR, have been at mostly slightly elevated levels on a gradual downward trend from 470 km/s to 400 km/s. Density has been mostly near average. Total magnetic field strength has been weak to moderate at 8nT or below, with a decreasing trend. Bz has varied mostly weakly, between +/- 5nT, again with a weakening trend. Phi angle was negative (towards the Sun) throughout. Geomagnetic activity was initially Active (Kp 4) at 24/0000-0300UTC, then became predominantly Quiet to Unsettled (Kp 0-3), with a reducing trend.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was marginally above normal background levels at first, but declined to background over the 24 hour period.

GOES16 high energy (greater than 2MeV) electron flux was at background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a steady trend. At 25/0000UTC the 24-hour integrated fluence observation was 1.18e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: M-class flares are likely throughout from AR3561 or AR3559, with a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: There is potential for at least three CME glancing blows in the coming days. In addition, these CMEs are all expected at a similar time - from later on day 1 (25 Jan) to early on day 2 (26 Jan), with the possibility that they either combine or arrive one after the other, perhaps increasing any geomagnetic effects.

Geomagnetic activity is expected to be mostly Quiet to Unsettled initially, with an increase expected later day 1 into day 2, perhaps step-wise if the various CMEs arrive separately, with G1-G2/Minor-Moderate Storms likely and a slight chance of G3/Strong Storms. Geomagnetic activity should then gradually return to Quiet levels by day 4 (28 Jan) after any residual CME

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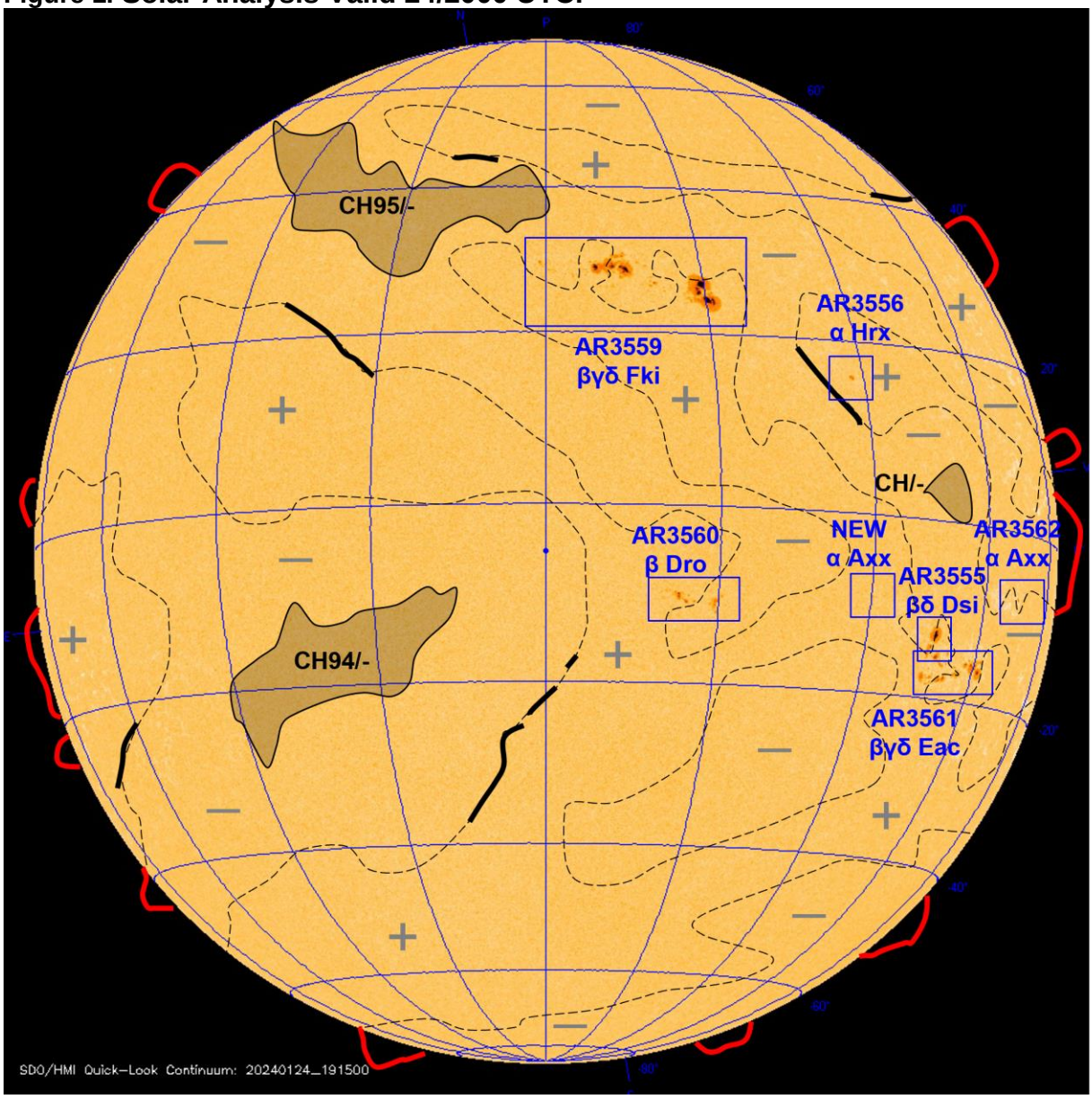
effects have waned.

Energetic Particles / Solar Radiation: There is a slight chance of radiation storms throughout, due to the magnetic complexity and flare history of both AR3559 and AR3561.

The high energy electron (greater than 2MeV) flux is uncertain due to the effects of multiple possible CME arrivals on the forecast, but may rise towards the end of the period. There is a slight chance of electron fluence exceeding Active (1e8 integrated pfu) by the end of day 4 (28 Jan), but with significant uncertainty.

Figure 1. Solar Analysis Valid 24/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There have been numerous CMEs seen in coronagraph imagery in recent days. The majority of these have been either northward or southward directed, but there is potential for several glancing blows in the forecast period. Of these, there are two CMEs which emerged on 22 and 23 January which are mostly directed below Earth's orbit, but are likely to give some impact at Earth. A third, also seen on 23 January, has the material of the CME directed well to the north of Earth, but a wider shock signature was visible in coronagraph imagery and this may also give a glancing blow.

In addition, these CMEs are all expected at a similar time - from later on day 1 (25 Jan) to early on day 2 (26 Jan), with the potential for them to either combine or arrive one after the other, perhaps increasing any geomagnetic effects.

A weak equatorial coronal hole has been identified in the western hemisphere of the disc, but this is unlikely to enhance the solar wind significantly.

Overall, geomagnetic activity is expected to be mostly Quiet to Unsettled initially, with an increase expected later day 1 into day 2, perhaps step-wise if the various CMEs arrive separately, with G1-G2/Minor-Moderate Storms likely and a slight chance of G3/Strong Storms, should the CMEs combine favourably for this to occur. Geomagnetic activity should then gradually return to Quiet levels by day 4 (28 Jan) after any residual CME effects have waned.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	50	70	20	5
Strong	G3	No	5	15	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/1559	Partial	Filament	South-centre disc	620 km/s	25/2100 UTC	Glancing blow
23/0700	Partial	AR3559	Northeast	840 km/s	26/0000 UTC	Mostly shock
23/1230	Partial	AR3561	Southwest	650 km/s	26/0600 UTC	Glancing blow

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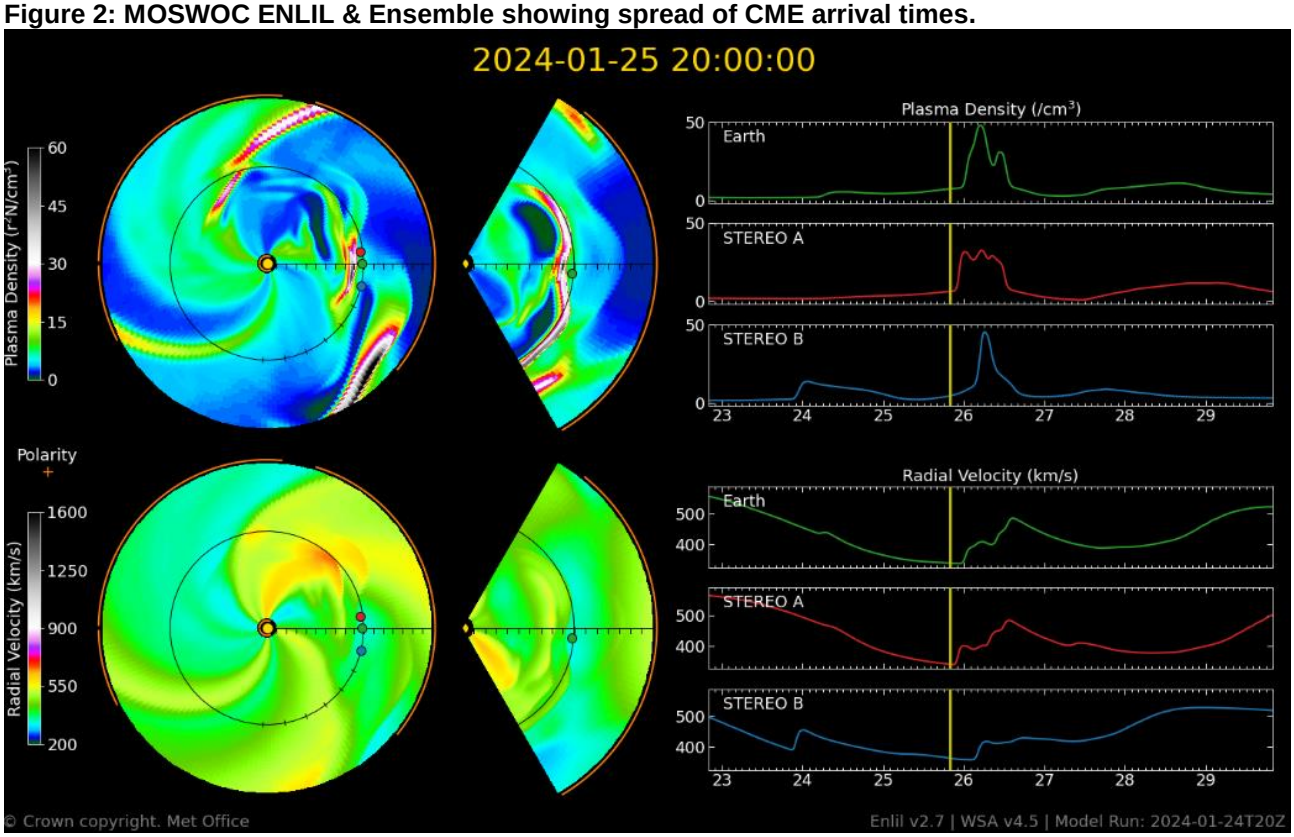
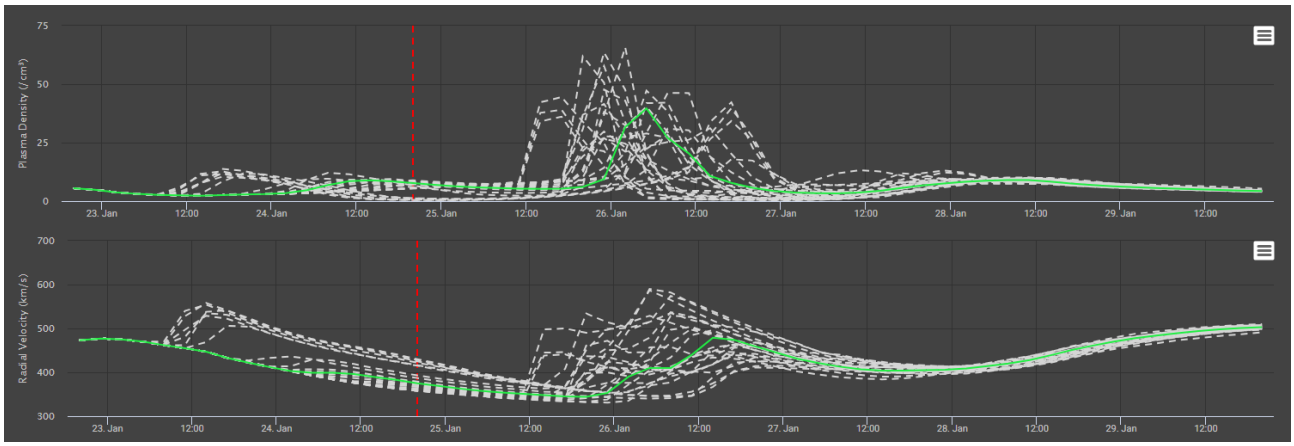
Figure 2: MOSWOC ENLIL & Ensemble showing spread of CME arrival times.





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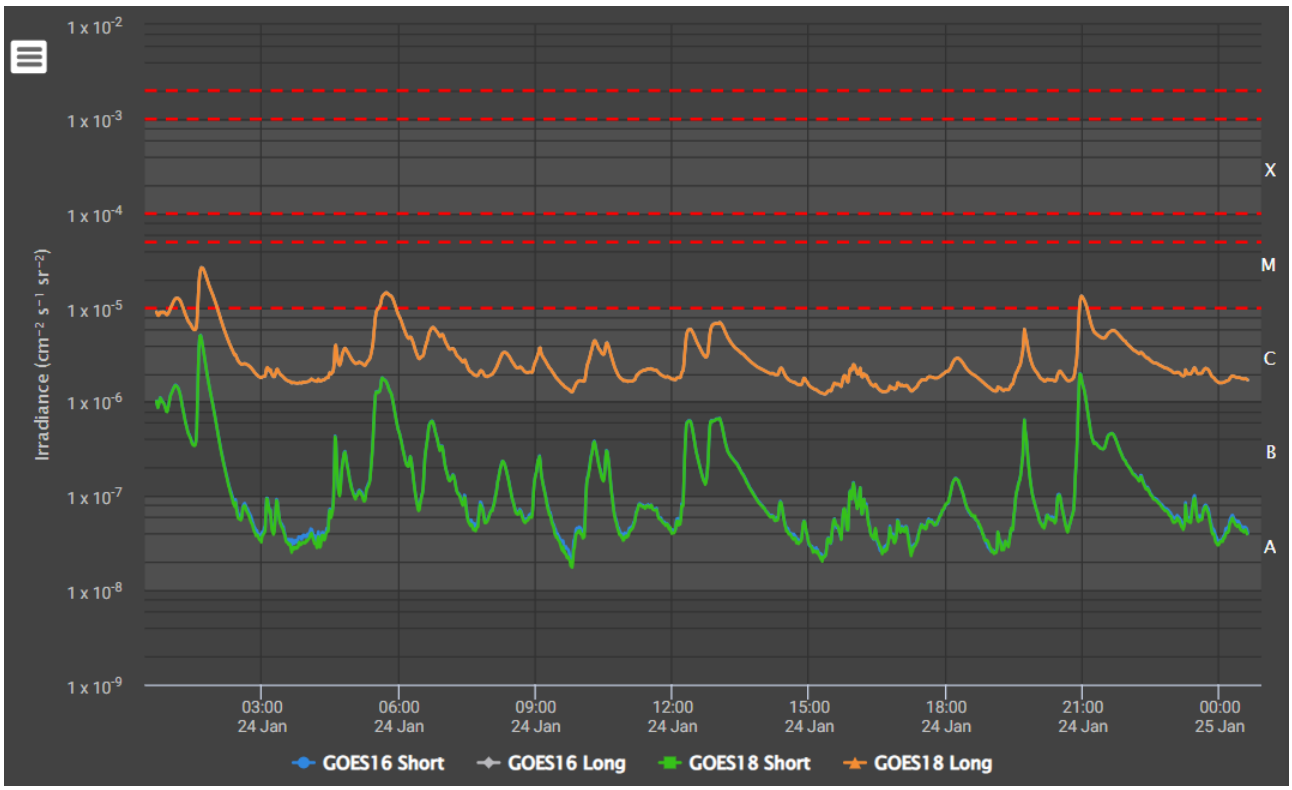
Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate, with numerous M-class flares from AR3559 and AR3561, peaking with a M2.6 at 24/0140 UTC.
There are currently seven sunspots on the visible disc. AR3549 has rotated out of view around the southwestern limb. AR3561 and AR3559 are the two largest, most complex and active regions, both showing significant magnetic complexity and contain delta regions, though both also displaying some minor decay in areal extent recently. AR3555 is situated close to AR3561, a spot is now evident in its southern trailing portion. These two spots are magnetically linked, adding to the overall flare risks. The remaining spot regions are small and simple at present. Activity is likely to remain Moderate, with a slight chance of an isolated X-flare.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: 24 Hour X-ray Trace



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Solar Radiation Storms - (High Energy Protons):

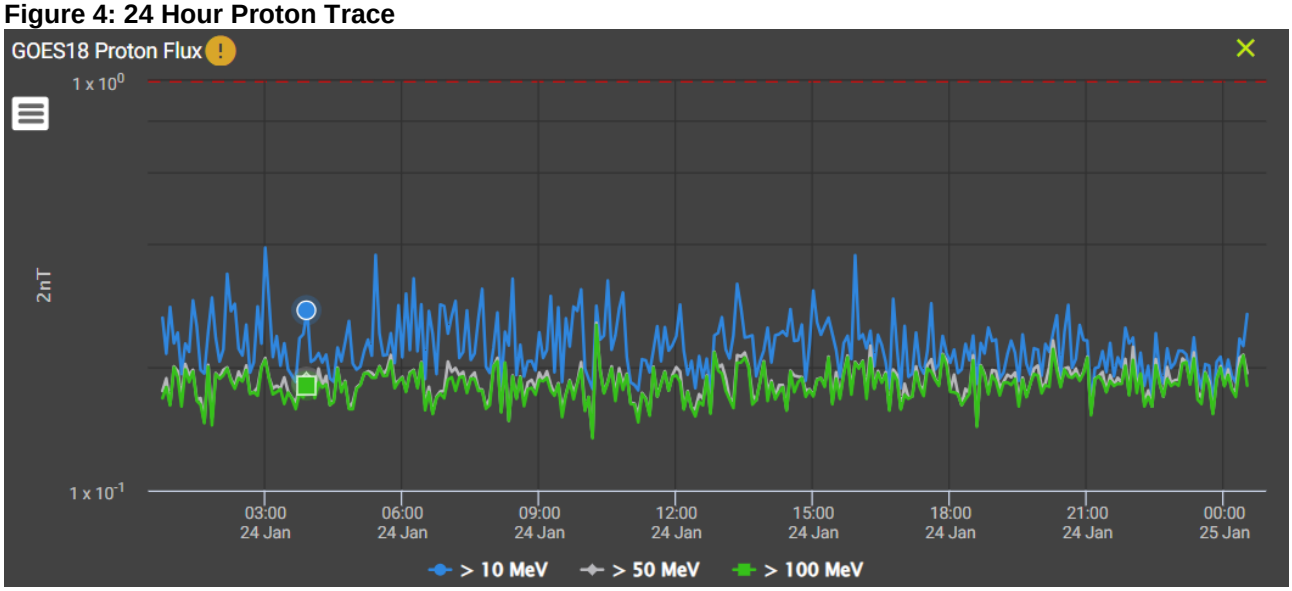
GOES18 high energy (greater than 10MeV) proton flux is at background levels.

There is a slight chance of radiation storms throughout due to both AR3559 and AR3561 being located in the western hemisphere. Both of these regions are magnetically complex, with a risk of larger and stronger flares than they have recently exhibited.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	20	20	20	20
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: 24 Hour Proton Trace



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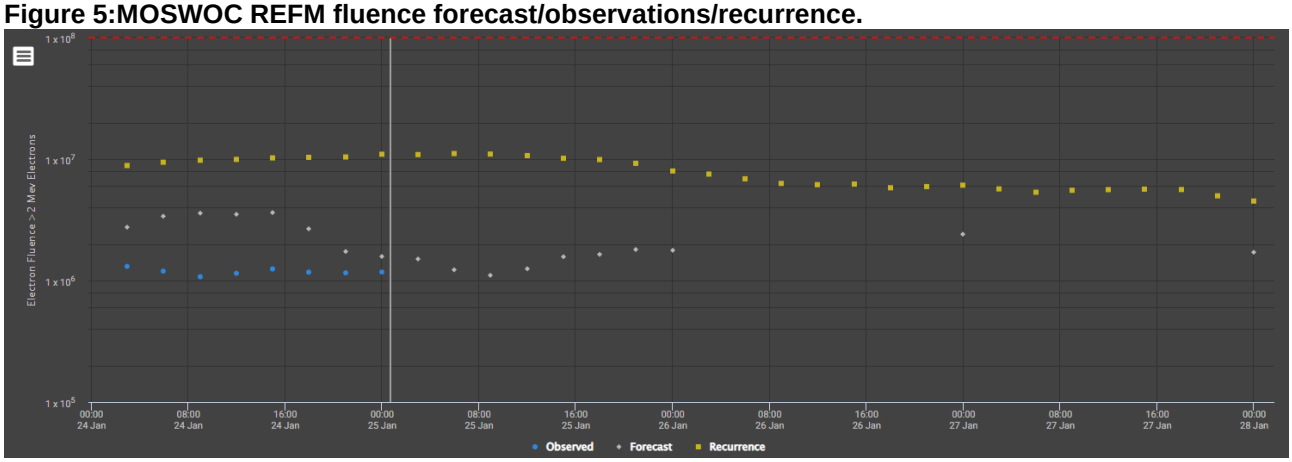
High Energy Electrons Event (≥ 2MeV):

The high energy electron (greater than 2MeV) flux is uncertain due to the effects of multiple possible CME glancing blows on the forecast, but will most likely remain at background levels for much of this period. Towards the end of the period, as CME effects are starting to wane, then electron flux may start to rise. This will be especially true if the CME arrival(s) give stronger geomagnetic activity. However, this is also assuming no further Earth directed CMEs emerge, and at present further CMEs are considered a likely scenario.

Electron fluence is likely to stay below Active (1e8 integrated pfu) for much of this period, but there is potential for a rise later in the period. REFM is currently providing a good steer for the forecast trend, though will not be taking into account any potential CME impact, and will become increasingly unreliable in the coming days.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5:MOSWOC REFM fluence forecast/observations/recurrence.



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